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Sir:

Transmitted herewith for filing is the patent application of Inventor(s):

**Anthony Joseph Nadalin, Bruce Arland Rich,
Theodore Jack London Shrader, Julianne Yarsa**For: **MANAGING AND EXTENDING ATTRIBUTE VALUES FOR PUBLIC KEY
CRYPTOGRAPHY STANDARDS**

Enclosed are also:

- ☒ 25 Pages of Specification including an Abstract
☒ 12 Pages of Claims
☒ 6 Sheet(s) of Drawings
☒ A Declaration and Power of Attorney
☒ Form PTO 1595 and assignment of the invention to IBM Corporation

CLAIMS AS FILED

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Volel Emile

Reg. No. 39,969

Intellectual Property Law Dept.

IBM Corporation

11400 Burnet Road 4054

Austin, Texas 75758

Telephone: (512) 823-1005

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**MANAGING AND EXTENDING ATTRIBUTE VALUES
FOR PUBLIC KEY CRYPTOGRAPHY STANDARDS**

BACKGROUND OF THE INVENTION

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1. Technical Field

The present invention relates generally to an improved data processing system and in particular to a method and an apparatus for implementing Public Key
10 Cryptography Standards (PKCS). Still more particularly, the present invention provides a method for manipulating PKCS-attributes and user-defined attributes in a PKCS compliant system.

15 **2. Description of the Related Art**

Public Key Cryptography Standard (PKCS) is a set of documents published by RSA Laboratories and serves to define data types and algorithms used in public-key cryptography. Public-key cryptography is a technology in
20 which encryption and decryption involve the use of a *public key* and a *private key*, and either can encrypt and/or decrypt data. A user gives his or her public key to other users, keeping the private key to himself or herself. Data encrypted with a public key can be
25 decrypted only with the corresponding private key, and vice versa.

The PKCS set of standards has been developed to assure that software using cryptography at two different sites could work together even when the software is
30 developed by different vendors for a variety of purposes. In particular, standards are being developed to allow agreement on digital signatures, digital enveloping,

digital certification, and key agreement. However, interoperability requires strict adherence to communicable formats, and PKCS provides a basis for interoperable standards in heterogeneous environments.

5 The present set of PKCS standards includes:

PKCS #1: RSA Encryption Standard;

PKCS #3: Diffie-Hellman Key Agreement Standard;

PKCS #5: Password-Based Encryption Standard;

PKCS #6: Extended-Certificate Syntax Standard;

10 PKCS #7: Cryptographic Message Syntax Standard;

PKCS #8: Private-Key Information Syntax Standard;

PKCS #9: Selected Attribute Types;

PKCS #10: Certification Request Syntax Standard;

PKCS #11: Cryptographic Token Interface Standard;

15 PKCS #12: Personal Information Exchange Syntax
Standard;

PKCS #13: Elliptic Curve Cryptography Standard; and

PKCS #15: Cryptographic Token Information Format
Standard.

20 Two independent levels of abstraction have been
provided by these standards. The first level is message
syntax, and the second level is specific encryption
algorithms. The intention has been that message syntax
and specific algorithms should be orthogonal. In other
25 words, a standard for the syntax of digitally signed
messages should be able to work with any public-key
algorithm, not just RSA, the public-key algorithm
invented by Rivest, Shamir, and Adleman involving
exponentiation modulo the product of two large prime
30 numbers; and a standard for RSA should be applicable to
many different message syntax standards.

PKCS provides definitions of data objects that may be created, sent, and received between parties to a communication, while other standards are used to define the encoding syntax of the data streams containing these
5 types of data objects. Abstract Syntax Notation One, abbreviated ASN.1, is a notation for describing abstract types and values. The Basic Encoding Rules (BER) for ASN.1 give one or more ways to represent any ASN.1 value as an octet string. The Distinguished Encoding Rules
10 (DER) for ASN.1 are a subset of BER, and give exactly one way to represent any ASN.1 value as an octet string. DER is intended for applications in which a unique octet string encoding is needed, as is the case when a digital signature is computed on an ASN.1 value. ASN.1 and DER
15 encoding are general purpose methods that can be applied to many domains in addition to PKCS.

One of the PKCS standard documents, PKCS #9, defines a set of attributes that can be used in other PKCS standards. PKCS #9 defines selected attribute types for
20 use with various types of other data objects within other PKCS standards, such as PKCS #6 extended certificates and PKCS #7 cryptographic messages. For example, PKCS #7 defines the syntax for several cryptographically protected messages, including encrypted messages and
25 messages with digital signatures. PKCS #7 also allows arbitrary attributes, such as signing time, to be authenticated along with the content of a message. Originally an outgrowth of Internet Privacy-Enhanced Mail, PKCS #7 has become the basis for the widely
30 implemented Secure/Multipurpose Internet Mail Extensions (S/MIME) secure electronic mail specification, an Internet e-mail security standard that employs public key

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encryption. PKCS #7 has become a basis for message security in systems as diverse as the Secure Electronic Transaction (SET) specification for bank systems.

Since PKCS #9 provides attributes to support other
5 components in the PKCS set of standards, it is important that any software that processes PKCS #9 attributes handle these attributes in a robust manner. For example, a software application could be written such that it has knowledge of attributes defined as part of the PKCS #9
10 standard, and the application could treat unknown attributes as "undefined" attributes. However, given the fact that this set of standards continues to evolve, it is important for software that handles PKCS #9 attributes can handle "extended" attribute or user-defined
15 attributes. Beyond the attributes that are defined as part of the standard, a software developer may desire to process a user-defined set of attributes along with the standard list of attributes.

Therefore, it would be advantageous to have an
20 architecture and a method for manipulating PKCS attributes that allows a data processing system to be extended to accommodate additional attributes.

SUMMARY OF THE INVENTION

A method and system for processing PKCS-attributes and user-defined attributes is provided. Attributes are
5 registered with a PKCS9 gateway class, and the attributes include user-defined attributes and PKCS-standard defined attributes. Each of the registered attributes is associatively stored with an identifier. An object-oriented method in the PKCS9 gateway class may be
10 called with a parameter containing an object identifier for an attribute. An attribute mapping data structure is searched using the object identifier in the received parameter, and in response to finding a matching object identifier, a class identifier that has been
15 associatively stored with the matching object identifier is retrieved from the attribute mapping data structure. A method in the class identified by the class identifier is then called. The called method may include an operation for construction, attribute conversion to and
20 from DER-encoding, attribute differentiation, and attribute value extraction. A class hierarchy of attribute types is based on an abstract class for all attribute objects with a subclass for undefined attributes and a subclass for defined attributes. The
25 subclass for defined attributes is further decomposed into a subclass for each PKCS-defined attribute and a subclass for each user-defined attribute.

BRIEF DESCRIPTION OF THE DRAWINGS

The novel features believed characteristic of the invention are set forth in the appended claims. The invention itself, however, as well as a preferred mode of use, further objectives and advantages thereof, will best be understood by reference to the following detailed description of an illustrative embodiment when read in conjunction with the accompanying drawings, wherein:

10 **Figure 1** is a exemplary representation of a distributed data processing system in which the present invention may be implemented;

Figure 2 is an exemplary block diagram of a data processing system that may be implemented as a server;

15 **Figure 3** is a diagram showing the Abstract Syntax Notation for the X.500 Attribute type;

Figure 4 is a diagram showing two examples of PKCS #9 attributes, each with sample values;

Figure 5 shows an example of DER-encoding in hexadecimal format of the two PKCS #9 objects shown in **Figure 4**;

Figure 6 is a class hierarchy diagram that shows an exemplary set of classes for use in the software methodology of the present invention for implementing PKCS-attribute-related operations in an extensible manner;

Figure 7A is a flowchart outlining an exemplary operation for requesting an attribute object via the PKCS9 class in accordance with an embodiment of the present invention;

Figure 7B is a diagram showing an example format of a user-defined attribute configuration file that maps attribute object identifiers to the classes that implement the attributes;

5 **Figure 7C** is a table showing an example of mappings from object identifiers to the classes that implement the attributes; and

10 **Figure 8** is a flowchart outlining an exemplary operation of the `getAttribute()` method for the PKCS9 class in accordance with a preferred embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention provides a software
5 methodology for managing PKCS #9 attributes that may be
associated with a variety of data objects. These data
objects are formatted according to other standards in the
PKCS set of standards. The data objects and their
associated attributes may be embedded within messages
10 that are sent within a distributed data processing system
between parties that desire certain types of security
features provided by the PKCS standards.

With reference now to the figures, and in
particular with reference to **Figure 1**, a pictorial
15 representation of a distributed data processing system is
depicted in which the present invention may be
implemented.

Distributed data processing system **100** is a network
of computers. Distributed data processing system **100**
20 contains network **102**, which is the medium used to provide
communications links between various devices and
computers connected within distributed data processing
system **100**. Network **102** may include permanent
connections, such as wire or fiber optic cables, or
25 temporary connections made through telephone connections.

In the depicted example, servers **104**, **114**, **116** and
118 are connected to network **102**. Storage units **106** and
122 are also connected to network **102**, providing backup
support for any or all of servers **104**, **114**, **116** and **118**.
30 In addition, clients **108**, **110** and **112** are also connected
to network **102**. These three clients may be, for example,

personal computers or network computers. Distributed data processing system **100** may include additional servers, clients, and other devices not shown.

In the depicted example, servers **104**, **114**, **116** and **118** provide storage for data from clients **108**, **110** and **112**. These four servers also provide data, such as boot files, operating system images, and applications to clients **108**, **110** and **112**. Clients **108**, **110** and **112** are clients to one or all of servers **104**, **114**, **116** and **118**.

In the depicted example, distributed data processing system **100** may be the Internet, with network **102** representing a worldwide collection of networks that use the TCP/IP suite of protocols to communicate with one another. At the heart of the Internet is a backbone of high-speed data communication lines between major nodes or host computers consisting of thousands of commercial, government, education, and other computer systems that route data and messages. Of course, distributed data processing system **100** also may be implemented as a number of different types of networks, such as, for example, an intranet or a local area network.

Figure 1 is intended as an example and not as an architectural limitation for the processes of the present invention.

The present invention may be embedded within a software application that provides some type of secure messages or cryptographic features to a user for a variety of purposes. For example, an application that employs the software methodology of the present invention may execute on any of the clients or servers shown in **Figure 1**. The application may use the present invention to create a data object representing an instance of a

PKCS #9 attribute, which is then associated with another PKCS-related data object and embedded within a PKCS #7 cryptographic message. The cryptographic message may then be sent between clients and/or servers in network
5 **102.**

With reference now to **Figure 2**, a block diagram of an exemplary data processing system which may be implemented as a server or client, such as server **104** or client **108** in **Figure 1**. Data processing system **200** may
10 be a symmetric multiprocessor (SMP) system including a plurality of processors **202** and **204** connected to system bus **206**. Alternatively, a single processor system may be employed. Also connected to system bus **206** is memory controller/cache **208**, which provides an interface to
15 local memory **209**. I/O bus bridge **210** is connected to system bus **206** and provides an interface to I/O bus **212**. Memory controller/cache **208** and I/O bus bridge **210** may be integrated as depicted.

Peripheral component interconnect (PCI) bus bridge
20 **214** connected to I/O bus **212** provides an interface to PCI local bus **216**. A number of modems **218-220** may be connected to PCI bus **216**. Typical PCI bus implementations will support four PCI expansion slots or add-in connectors. Communications links to network
25 computers **108-112** in **Figure 1** may be provided through modem **218** and network adapter **220** connected to PCI local bus **216** through add-in boards.

Additional PCI bus bridges **222** and **224** provide interfaces for additional PCI buses **226** and **228**, from
30 which additional modems or network adapters may be supported. In this manner, server **200** allows connections

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to multiple network computers. A memory-mapped graphics adapter **230** and hard disk **232** may also be connected to I/O bus **212** as depicted, either directly or indirectly.

Those of ordinary skill in the art will appreciate
5 that the hardware depicted in **Figure 2** may vary. For example, other peripheral devices, such as optical disk drives and the like, also may be used in addition to or in place of the hardware depicted. The depicted example is not meant to imply architectural limitations with
10 respect to the present invention.

The data processing system depicted in **Figure 2** may be, for example, an IBM RISC/System 6000, a product of International Business Machines Corporation in Armonk, New York, running the Advanced Interactive Executive
15 (AIX) operating system.

Before describing the software methodology of the present invention for processing PKCS #9 attributes, **Figures 3-5** provide some background information about the syntax and encoding of attributes that are used in the
20 PKCS set of standards.

With reference now to **Figure 3**, a diagram shows the Abstract Syntax Notation (ASN.1) for the X.500 Attribute type. An attribute is defined in the X.500 standard to be essentially a coupling of a unique object identifier
25 (ID) with some value. An attribute value can be composed of one or more items, and the data type of the items themselves depends upon the type of the attribute.

As stated, PKCS #9 defines a specific set of attributes. Currently, in the version 1.1 standard,
30 there are nine such attributes, described in more detail below in **Figure 6**. The definition of each includes its

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object identifier, the data type of its value, and whether its value is single-valued or multi-valued.

With reference now to **Figure 4**, a diagram shows two examples of PKCS #9 attributes, each with sample values.

5 EmailAddress attribute **400** is an example of a multi-valued attribute. The object identifier **402** has two value items, **404** and **406**. These values have ASN.1 data type IA5String, where IA5String is a sequence of ASCII characters. ContentType attribute is a
10 single-valued attribute **408**. The object identifier **410** has a single value **412** that is also an object identifier.

ASN.1 notation defines the data types, and any software application can implement data type definitions in any suitable way: a C struct, a Java object, and a
15 Pascal record are possible implementations. These disparate objects must be encodable in some standard way to ensure interoperability among the software implementing the defined objects. One way to accomplish this uniform encoding is through the Distinguished
20 Encoding Rules (DER), a method to transform an ASN.1-defined object into a byte array in standard format. In this way, a software entity on one system may implement an ASN.1 object in one fashion, encode it via DER, and transmit it to another software entity, which
25 can then parse the DER byte array into its own representation of the same ASN.1 object originally encoded.

With reference now to **Figure 5**, a figure shows DER-encoding in hexadecimal format for the two PKCS #9
30 objects depicted in **Figure 4**. In particular, encoding **502** is for EmailAddress and encoding **504** is for

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ContentType. The important feature of these encodings is that they are "distinguished" or unique.

As mentioned previously, an application may use the present invention to create a data object representing an
5 instance of a PKCS #9 attribute, which may then be associated with another PKCS-related data object and embedded within a message sent across a network. There are basically four operations that must be implemented within a robust application to fully support PKCS #9
10 attributes:

(1) An application should be able to build an attribute from its constituent parts, its object identifier, and its value.

(2) An application should be able to convert an
15 attribute object into a DER-encoded byte stream for transmission to other systems.

(3) An application should be able to convert a DER-encoded byte stream into an attribute object.

(4) An application should be able to distinguish one
20 attribute from another and extract an attribute's value information.

The PKCS #9 architecture outlined in this invention supports these PKCS attribute operations, such as construction, attribute conversion to and from
25 DER-encoding, attribute differentiation, and attribute value extraction. By implementing the software methodology of the present invention in an object-oriented programming language, such as Java, some of these operations may be facilitated by having very
30 specific attribute classes while other operations are facilitated by more general classes. The class hierarchy described below combines elements of specific and general

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classes to implement PKCS-attribute-related operations in a manner which is extensible to user-defined attributes. "User-defined attributes" may include attributes that have specific user purposes in specific applications,
5 i.e. attributes which are not contemplated as eventually becoming standard-defined attributes or are not promulgated as standard-defined attributes.

In addition, a "user-defined attribute" may also include attributes that were not part of the PKCS #9
10 standard when a software application implementing the present invention was deployed. At some later time, when an attribute that was previously recognized as a user-defined attribute then becomes part of the PKCS #9 standard, the application may be updated so that the
15 application recognizes the PKCS #9 standard-defined attribute and so that the attribute is no longer recognized as a user-defined attribute. In this manner, the present invention allows an application to be extended to user-created attributes and subsequent,
20 standard-defined attributes.

With reference now to **Figure 6**, a class hierarchy diagram shows an exemplary set of classes for use in the software methodology of the present invention for implementing PKCS-attribute-related operations in an
25 extensible manner. PKCSDerObject **600** is an abstract class representing any object that can be encoded into or decoded from a DER byte stream. All subclasses of PKCSDerObject must implement encode and decode methods.

DefinedAttribute **602** is an abstract class
30 representing any attribute that is "known" to the system; that is, those attributes that have individual class implementations and that are registered with the PKCS9

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class. The registration process is discussed below with respect to the PKCS9 gateway class **610**. The subclasses of DefinedAttribute **602** must implement a number of methods to return attribute-specific information such as the attribute's common name and whether the attribute is single-valued or multi-valued.

PKCS #9 standard-defined-attribute Classes **604** are a set of classes representing the attributes defined in PKCS #9. As of version 1.1 of the PKCS #9 standard, there are nine defined attributes: ChallengePassword, EmailAddress, SigningTime, ContentType, ExtendedCertificateAttributes, UnstructuredName, Countersignature, MessageDigest, and UnstructuredAddress. Additional classes can be added to this set as further versions of the PKCS #9 standard are developed and approved. All of these classes implement the abstract methods in their parent class, DefinedAttribute **602**.

User-defined-attribute Classes **606** are a set of classes representing ASN.1 Attribute types that are not defined in the PKCS #9 standard (and therefore not represented by a class in PKCS #9 standard-defined-attribute classes **604**) but that are known to the system and registered with the PKCS9 gateway class **610**. Like the standard PKCS #9 standard-defined-attribute classes **604**, user-defined-attribute classes must implement the abstract methods in DefinedAttribute.

UndefinedAttribute **608** represents any attribute that is unknown to the system. That is, there is not a specific class that implements the attribute, so the PKCS9 class **610** cannot map the attribute object identifier to an implementing class. The

UndefinedAttribute class **608** allows the decoding of arbitrary attributes that may be undefined on the system. The UndefinedAttribute class **608** includes an ObjectIdentifier data member which is the attribute OID
5 and a byte array data member which is the DER-encoding of the attribute value.

PKCS9 gateway class **610** serves as the gateway to all the attributes on the system, both known and unknown. It has a variety of getAttribute() methods that allow easy
10 instantiation of an attribute by OID and value, string name and value, or DER-encoding. PKCS9 gateway class **610** will interpret the input and return an instance of the proper DefinedAttribute or an UndefinedAttribute.

All attributes defined in the PKCS #9 standard (and
15 therefore represented by a class in PKCS #9 standard-defined-attribute classes **604**) are statically registered within the PKCS9 gateway class **610**. That is, the PKCS9 gateway class **610** has a mapping of each attribute's unique OID to the class that implements it.
20 To register user-defined attributes, the user must first implement the attribute as a subclass of DefinedAttribute since the PKCS9 gateway class **610** uses the abstract methods defined in DefinedAttribute and then enters the attribute OID and its implementing class in a
25 configuration file.

Figure 6 shows two user defined attributes:
"NetscapeComment", an attribute used in many applications yet not one of the attributes defined in the PKCS standard, and "SomeAttribute", an exemplary name chosen
30 to suggest a user-defined attribute for a particular application. When the PKCS9 gateway class **610** is first loaded, it will read a configuration file and internally

store the mapping information for OIDs of user-defined attributes. Thereafter, when a `getAttribute()` method is called and the PKCS9 gateway class **610** detects a user-defined OID in the input arguments, it will be able to access the proper class for attribute instantiation. This registration process and the basic means of obtaining an attribute via the PKCS9 gateway class **610** is discussed in more detail below with respect to **Figure 7**. The logic followed by the `getAttribute()` method is discussed in more detail further below with respect to **Figure 8**.

Note that a configuration file may be in a default location or may be in a location defined by a Java property defined in the `java.security` configuration file. If a configuration file is property-defined, the PKCS9 gateway class **610** must have permission to read the property. In either case, the PKCS9 gateway class **610** must have permission to read the configuration file itself.

Before discussing flowcharts for the algorithms associated with the present invention, it is useful to discuss the PKCS-attribute-related operations of construction, attribute conversion to and from DER-encoding, attribute differentiation, and attribute value extraction in more detail.

Constructing an attribute using the classes defined in the present invention can be accomplished in different ways, depending upon what information the user has at the time. If the type of the required attribute is known, then that attribute may be instantiated directly using a constructor that takes a meaningful data type. For example, if an `UnstructuredName` attribute is needed, that

attribute may be instantiated by calling the
UnstructuredName constructor that takes a String argument
(the name). There is no need to convert the name value
to the DER-encoding of its ASN.1 data type. As another
5 example, the ChallengePassword attribute may be
instantiated by calling the ChallengePassword constructor
that takes a char[] argument (the password). Note that
security-sensitive data, such as passwords, should not be
represented as String data types which are immutable.

10 If the user has an object identifier (OID) and some
value, but does not know to which attribute class the OID
corresponds, the PKCS9.getAttribute(ObjectIdentifier,
Object) method associated with the PKCS9 class, such as
the PKCS9 gateway class **610** shown in **Figure 6**, may be
15 used to construct the attribute. The PKCS9 class will
return an instance of the correctly defined attribute if
the attribute OID is known to the system or an instance
of UndefinedAttribute if the OID is unknown to the
system.

20 If the user has only a DER-encoded byte stream, the
PKCS9.getAttribute(byte[]) method may be used. This
method will extract the attribute OID from the byte
stream and then instantiate and return the proper
attribute object.

25 Another operation is the conversion of an attribute
object to a DER-encoded byte stream. Because all
attributes are subclassed from PKCSDerObject, each must
implement an encode() method. Converting an attribute
object to its DER-encoding requires a simple call to the
30 encode() method.

The reverse conversion of a DER-encoded byte stream
to an attribute object is also possible. Because all

attribute classes are subclassed from PKCSDerObject, each attribute class must implement a decode() method.

Explicitly creating an attribute object from a DER byte array requires using the attribute's default constructor
5 and then calling that object's decode() method.

Alternatively, the PKCS9 gateway class, such as PKCS9 gateway class **610** in shown in **Figure 6**, can be used to convert any DER-encoded attribute to an attribute object, and this relieves the user from having to know how to
10 instantiate an attribute object explicitly by knowing the attributes type and calling the appropriate constructor.

Other useful operations are attribute differentiation and value extraction. An important usability feature of attributes is the ability to easily
15 distinguish them from one another. Having a separate class implement each attribute allows the user to search for a particular attribute type using the "instanceof" operator. For example, X.509 extended certificates can include attributes. To find the signing time of an
20 extended certificate, one could cycle through the attribute objects in the certificate object using the "instanceof SigningTime" comparator. There is no need to examine OIDs values within the attribute objects to find the correct one.

25 It is also preferable to be able to extract the attribute value in a form that is immediately meaningful, rather than in a form that must be converted before use. For example, the value of an EmailAddress attribute can be extracted directly into an array of Strings. This
30 relieves the user from having to convert an internal representation of the value -- whether it be a DER byte

stream or a series of Objects, for example -- into Strings after value extraction.

With reference now to **Figure 7A**, a flowchart shows the request of an attribute object via the PKCS9 gateway class. The PKCS9 gateway class is loaded (step **702**). Upon loading, the static initializer block in this class is run. Static initialization includes reading in the data from the user-defined-attribute configuration file.

The user-defined-attribute configuration file is read (step **704**). The file is stored on disk either in a default location or in a location specified by a Java security property. If the latter, the PKCS9 gateway class must first read the Java property to find the file location, then access the file itself.

In the course of execution, a Java program may request an attribute instance by calling a PKCS9.getAttribute() method, passing in the appropriate arguments (step **706**). The logic followed by the PKCS9.getAttribute() method (step **708**) is described more fully in **Figure 8**. If there are more attributes to process (step **710**), then control is transferred to step **706**. Otherwise, the request of the Attribute object is completed.

With reference now to **Figure 7B**, a diagram shows an example format of a user-defined attribute configuration file that maps attribute object identifiers to the classes that implement the attributes. The PKCS9 gateway class reads mappings, e.g., at initialization time, in configuration file **712** and stores them internally in an appropriate data structure. In this example, object identifier **714** maps to class **716** and object identifier **718** maps to class **720**.

With reference now to **Figure 7C**, a table shows an example of mappings from object identifiers to the classes that implement the attributes. The first nine entries are PKCS #9 standard-defined-attribute classes where both the object identifier and class names are predefined. Since these values are fixed, they do not need to be stored in the configuration file. Rather, the information in the configuration file is added to the attribute mappings after the predefined values. As one of ordinary skill in the art will appreciate, the attribute mappings shown in **Figure 7C** could be implemented as a hash table, an association list, or similar data structure. This set of mappings will contain the object identifier and the class name for all registered attributes, including the PKCS #9 standard-defined-attribute classes and extended or user-defined attributes.

When a "get"-type method in the PKCS9 gateway class is invoked, the object identifier is extracted from the argument, the class name associated with the object identifier is determined from the set of mappings, and a constructor in the associated (i.e. mapped) class is called. The PKCS9 "get" method then returns an instance of a specific defined attribute, or an instance of an UndefinedAttribute if the object identifier does not have a class mapping.

With reference now to **Figure 8**, a flowchart shows the logic of the getAttribute() method for the PKCS9 gateway class. This figure is an expansion of step 708 in **Figure 7A**. Once a PKCS9.getAttribute() method is called, the attribute object identifier is extracted from the input arguments (step 800). Depending on the

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signature of the `getAttribute()` method, the OID may be in String form, in `ObjectIdentifier` form, or in a DER-encoded byte array. In each case, the PKCS9 gateway class is able to convert the OID to the form in which the
5 object identifiers in the OID-class mappings for the PKCS9 gateway class are stored.

The PKCS9 class determines if the requested OID is one that has been registered, either statically (as an attribute class corresponding to the standard-defined
10 PKCS #9 attributes) or at runtime through the user-defined attribute configuration file (step **802**).

If the PKCS gateway class has found a registered OID, then a constructor of the class mapped to that OID is called with the value argument passed to the
15 `PKCS9.getAttribute()` method (step **804**). The specific attribute constructor will return an attribute instance to the `PKCS9.getAttribute()` method.

If the PKCS9 gateway class has not found a registered OID, then the constructor of the
20 `UndefinedAttribute` class is called (step **806**). This constructor will return an `UndefinedAttribute` instance to the `PKCS9.getAttribute()` method. The `PKCS9.getAttribute()` method returns the attribute back to its caller (step **808**).

25 The programming language for the preferred embodiment of this invention is Java, but as one of ordinary skill in the art will appreciate, implementation could be in a wide variety of programming languages, such as C, Pascal, C++, and so forth. Implementation in an
30 object-oriented language, such as C++, would be easier than in a language like C that is not object-oriented.

In summary, the architecture outlined in the present invention provides several usability features for PKCS attributes, including those that are not defined in the PKCS #9 standard:

5 (1) Distinct classes for each defined attribute allows for easy instantiation either directly or through the PKCS9 gateway class.

 (2) Distinct classes for each defined attribute allows for easy differentiation between attributes. A
10 specific attribute type can be found by using the "instanceof" operator with no need to examine internal data members.

 (3) Distinct classes for each defined attribute allows attribute values to be extracted in forms
15 meaningful to the user. For example, the value of a SigningTime attribute is known to be a Date object, and is directly retrievable and usable as such. There is no need to extract values generically as Objects or as byte arrays (DER-encodings) which then must be converted to
20 usable objects.

 (4) All attributes implement encode and decode methods for easy conversion to and from DER byte streams.

 (5) Both defined and undefined attributes are supported.

25 (6) The architecture is extendible so that new attributes can be implemented and registered with the system.

 It is important to note that, while the present invention has been described in the context of a fully
30 functioning data processing system, those of ordinary skill in the art will appreciate that the processes of the present invention are capable of being distributed in

the form of a computer readable medium of instructions and a variety of forms, and that the present invention applies equally regardless of the particular type of signal bearing media actually used to carry out the
5 distribution. Examples of computer readable media include recordable-type media such a floppy disc, a hard disk drive, a RAM, and CD-ROMs and transmission-type media such as digital and analog communications links.

The description of the present invention has been
10 presented for purposes of illustration and description but is not intended to be exhaustive or limited to the invention in the form disclosed. Many modifications and variations will be apparent to those of ordinary skill in the art. For example, this general architecture can be
15 utilized in a variety of operating systems. It can also be implemented in different programming languages. It can also be extended to include new PKCS attributes as the Public Key Cryptography Standards evolve over time. The embodiment was chosen and described in order to best
20 explain the principles of the invention and the practical application, and to enable others of ordinary skill in the art to understand the invention for various embodiments with various modifications as are suited to the particular use contemplated.

CLAIMS:

What is claimed:

1. A method in a data processing system for managing
5 data attributes, the method comprising the steps of:
 registering attributes with a PKCS9 gateway class,
 wherein the attributes include user-defined attributes
 and PKCS-standard (Public Key Cryptography Standards)
 defined attributes; and
10 associatively storing an identifier for each of said
 attributes.
2. The method of claim 1 further comprising:
 calling a first object-oriented method in the PKCS9
15 gateway class, wherein the first object-oriented method
 receives a parameter comprising an object identifier for
 an attribute.
3. The method of claim 2 further comprising:
20 searching an attribute mapping data structure using
 the object identifier in the received parameter;
 in response to a determination of a matching object
 identifier in the attribute mapping data structure,
 retrieving a class identifier associatively stored with
25 the matching object identifier in the attribute mapping
 data structure; and
 calling a second object-oriented method in a class
 identified by the retrieved class identifier.
- 30 4. A method in a data processing system for managing
 data attributes, the method comprising the steps of:

invoking a first object-oriented method to process
an attribute object, wherein the first object-oriented
method is defined in an abstract class for attribute
objects with a subclass for undefined attributes and a
5 subclass for defined attributes, wherein the subclass for
defined attributes is further comprised of a subclass for
each PKCS-defined (Public Key Cryptography Standards)
attribute and a subclass for each user-defined attribute;

invoking a second object-oriented method to process
10 an attribute object, wherein the second object-oriented
method is defined in a PKCS9 gateway class; and

in response to invoking the first object-oriented
method or the second object-oriented method, processing
the result returned by the first object-oriented method
15 or the second object-oriented method.

5. The method of claim 4, where a PKCS compatible
attribute is a unique object identifier and value, as
defined by the Abstract Syntax Notation (ASN.1) for the
20 X.500 Attribute type.

6. The method of claim 4, wherein each defined attribute
is implemented as a separate class.

25 7. The method of claim 4, wherein each defined attribute
is registered with the PKCS9 gateway class.

8. The method of claim 7, wherein PKCS-defined attributes
are registered statically with the PKCS9 gateway class.

30

9. The method of claim 7, wherein the user-defined
attributes are registered with the PKCS9 gateway class by

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reading a configuration file when the PKCS9 gateway class is initially loaded.

10. The method of claim 4, wherein the second
5 object-oriented method determines a type of the attribute object by performing an instanceof comparison to registered attributes.

11. The method of claim 4, wherein the attribute object
10 is constructed using a constructor method in a class associated with a PKCS-compatible attribute.

12. The method of claim 4 wherein, in response to
determining an object identifier and a value associated
15 with the object identifier and determining the object identifier is registered with the PKCS9 gateway class, the PKCS9 gateway class returns an instance of a registered attribute.

20 13. The method of claim 4 wherein, in response to determining a DER-encoded byte stream with an object identifier, the second object-oriented method in the PKCS9 gateway class returns an instance of a PKCS-compatible attribute.

25

14. The method of claim 13 wherein, in response to
determining the object identifier from the DER-encoded
byte stream is not registered with the PKCS9 gateway
class, an instance of an undefined attribute is returned
30 with the value being a DER-encoded byte stream.

15. The method of claim 13 wherein, in response to determining the object identifier from the DER-encoded byte stream is registered with the PKCS9 gateway class, an instance of an attribute with the object identifier is
5 returned.

16. The method of claim 4, wherein a registered attribute object is encoded to a DER-encoded byte stream by using the first object-oriented method for encoding the
10 attribute object.

17. The method of claim 4, wherein a registered attribute object represented as a DER-encoded byte stream is decoded to an attribute object by using the second
15 object-oriented method for decoding the attribute object.

18. The method of claim 4, wherein a second object-oriented method in the PKCS9 gateway class extracts attribute values into forms, wherein the forms
20 are strings, numbers, and/or other non-abstract data types

19. A data processing system for managing data attributes, the data processing system comprising:
25 registering means for registering attributes with a PKCS9 gateway class, wherein the attributes include user-defined attributes and PKCS-standard (Public Key Cryptography Standards) defined attributes;
 storing means for associatively storing an
30 identifier for each of said attributes.

20. The data processing system of claim 19 further comprising:

calling means for calling a first object-oriented
5 method in the PKCS9 gateway class, wherein the first
object-oriented method receives a parameter comprising an
object identifier for an attribute.

21. The data processing system of claim 20 further
10 comprising:

searching means for searching an attribute mapping
data structure using the object identifier in the
received parameter;

retrieving means for retrieving, in response to a
15 determination of a matching object identifier in the
attribute mapping data structure, a class identifier
associatively stored with the matching object identifier
in the attribute mapping data structure; and

calling means for calling a second object-oriented
20 method in a class identified by the retrieved class
identifier.

22. A data processing system for managing Public Key
Cryptography Standards (PKCS) compatible attributes, the
25 data processing system comprising:

first constructing means for constructing a new
instance of an attribute object;

first differentiating means for differentiating
between attribute objects of different types;

30 converting means for converting an instance of an
attribute object to and/or from DER-encoding;

first extracting means for extracting values associated with an attribute object;

extending means for extending a set of attributes with user-defined types; and

5 first registering means for registering an attribute class with a PKCS9 gateway class.

23. The data processing system of claim 22, where a PKCS compatible attribute is a unique object identifier and
10 value, as defined by the Abstract Syntax Notation (ASN.1) for the X.500 Attribute type.

24. The data processing system of claim 22 further comprising:

15 an abstract attribute object class with an undefined attribute object subclass and a defined attribute object subclass, wherein the defined attribute object subclass is further comprised of a subclass for each PKCS-defined attribute object and a subclass for each user-defined
20 attribute object.

25. The data processing system of claim 22 further comprising:

second constructing means for constructing wherein a
25 new instance of an attribute object using a class constructor.

26. The data processing system of claim 22 further comprising:

30 third constructing means for constructing a new instance of a PKCS-compatible attribute object is constructed using the PKCS9 gateway class if an attribute

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object identifier and a class implementing that attribute are registered.

27. The data processing system of claim 22 further
5 comprising:

fourth constructing means for constructing a new instance of a PKCS-compatible attribute object using the PKCS9 gateway class based on a DER-encoded byte stream.

10 28. The data processing system of claim 22 further comprising:

second differentiating means for differentiating a type for an attribute object determined by performing an instanceof comparison to registered attribute classes.

15

29. The data processing system of claim 22 further comprising:

encoding means for encoding an attribute object to a DER-encoded object by using an encode method of the
20 attribute object.

30. The data processing system of claim 22 further comprising:

decoding means for decoding an attribute object
25 represented as a DER-encoded string to an attribute object by using a decode method of the attribute object.

31. The data processing system of claim 22 further comprising:

30 second extracting means for extracting the PKCS9 gateway class returns attribute values, wherein the

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values are represented as strings, numbers, and/or other non-abstract data types.

32. The data processing system of claim 22 further
5 comprising:

second registering means for registering a
PKCS-compatible attribute is registered with the PKCS9
gateway class.

10 33. The data processing system of claim 32 further
comprising:

third registering means for registering an attribute
defined by the Public Key Cryptography Standards is
registered with the PKCS9 gateway class.

15

34. The data processing system of claim 32 further
comprising:

fourth registering means for registering wherein
user-defined attributes are registered with the PKCS9
20 gateway class by reading a configuration file when the
PKCS9 gateway class is initially loaded.

35. A computer program product in a computer-readable
medium for use in a data processing system for managing
25 data attributes, the computer program product comprising:

first instructions for registering attributes with a
PKCS9 gateway class, wherein the attributes include
user-defined attributes and PKCS-standard (Public Key
Cryptography Standards) defined attributes;

30 second instructions for associatively storing an
identifier for each of said attributes.

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36. The computer program product of claim 35 further comprising:

instructions for calling a first object-oriented
5 method in the PKCS9 gateway class, wherein the
object-oriented method receives a parameter comprising an
object identifier for an attribute.

37. The computer program product of claim 36 further
10 comprising:

instructions for searching an attribute mapping data
structure using the object identifier in the received
parameter;

instructions for retrieving, in response to a
15 determination of a matching object identifier in the
attribute mapping data structure, a class identifier
associatively stored with the matching object identifier
in the attribute mapping data structure; and

instructions for calling a second object-oriented
20 method in a class identified by the retrieved class
identifier.

38. A computer program product on a computer-readable
medium for use in a data processing system for managing
25 Public Key Cryptography Standards (PKCS) compatible
attributes, the computer program product comprising:

instructions for constructing a new instance of an
attribute object;

instructions for differentiating between attribute
30 objects of different types;

instructions for converting an instance of an
attribute object to and from DER-encoding;

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instructions for extracting values associated with an attribute object; and

instructions for extending a set of attributes with user-defined types; and

5 instructions for registering an attribute class with a PKCS9 gateway class.

39. The computer program product of claim 38, where a PKCS compatible attribute is a unique object identifier
10 and value, as defined by the Abstract Syntax Notation (ASN.1) for the X.500 Attribute type.

40. The computer program product of claim 38, wherein an abstract attribute object class with an undefined
15 attribute object subclass and a defined attribute object subclass, wherein the defined attribute object subclass is further comprised of a subclass for each PKCS-defined attribute object and a subclass for each user-defined attribute object.

20 41. The computer program product of claim 38, wherein a new instance of a PKCS-compatible attribute object is constructed using a class constructor.

25 42. The computer program product of claim 38, wherein a new instance of a PKCS-compatible attribute object is constructed using the PKCS9 gateway class if an attribute object identifier and a class implementing that attribute is registered.

30 43. The computer program product of claim 38, wherein a new instance of a PKCS-compatible attribute object is

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constructed using the PKCS9 gateway class based on a DER-encoded byte stream.

44. The computer program product of claim 38, wherein a
5 type for an attribute object is determined by performing an instance of comparison to registered attribute classes.

45. The computer program product of claim 38, wherein an
attribute object is encoded to a DER-encoded object by
10 using an encode method of the attribute object.

46. The computer program product of claim 38, wherein an
attribute object represented as a DER-encoded string is
decoded to an attribute object by using a decode method
15 of the attribute object.

47. The computer program product of claim 38, wherein
the PKCS9 gateway class returns attribute values, wherein
the values are represented as strings, numbers, and/or
20 other non-abstract data types.

48. The computer program product of claim 38, wherein a
PKCS-compatible attribute is registered with the PKCS9
gateway class.

25

49. The computer program product of claim 48, wherein an
attribute defined by the Public Key Cryptography
Standards is registered with the PKCS9 gateway class.

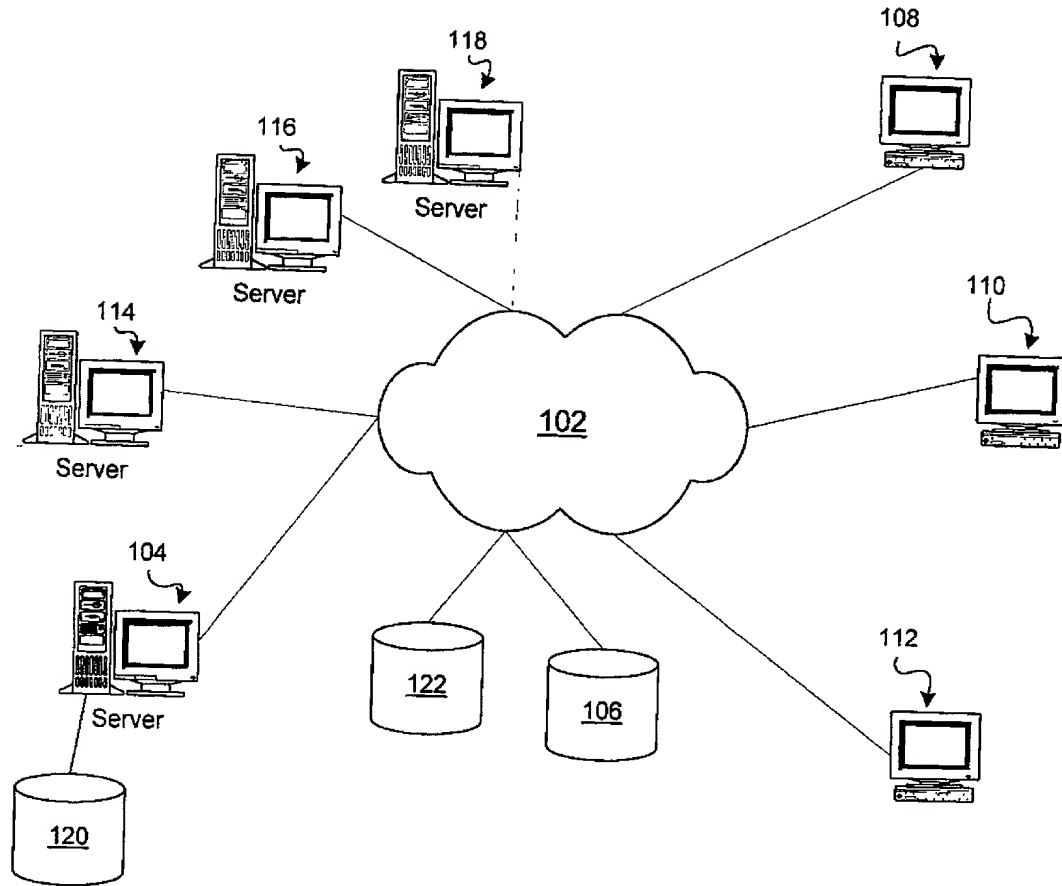
30 50. The computer program product of claim 48, wherein
user-defined attributes are registered with the PKCS9

gateway class by reading a configuration file when the PKCS9 gateway class is initially loaded.

ABSTRACT OF THE DISCLOSURE**MANAGING AND EXTENDING ATTRIBUTE VALUES
FOR PUBLIC KEY CRYPTOGRAPHY STANDARDS**

5

A method and system for processing PKCS-attributes and user-defined attributes is provided. Attributes are registered with a PKCS9 gateway class, and the attributes include user-defined attributes and PKCS-standard defined
10 attributes. Each of the registered attributes is associatively stored with an identifier. A method in the PKCS9 gateway class may be called with a parameter containing an object identifier for an attribute. An attribute mapping data structure is searched using the
15 object identifier in the received parameter, and in response to finding a matching object identifier, a class identifier that has been associatively stored with the matching object identifier is retrieved from the attribute mapping data structure. A method in the class
20 identified by the class identifier is then called. The called method may include an operation for construction, attribute conversion to and from DER-encoding, attribute differentiation, and attribute value extraction. A class hierarchy of attribute types is based on an abstract
25 class for all attribute objects with a subclass for undefined attributes and a subclass for defined attributes. The subclass for defined attributes is further decomposed into a subclass for each PKCS-defined attribute and a subclass for each user-defined attribute.



100
Network
Figure 1
AUS990800US1

The diagram illustrates a computer system architecture. At the top, two processors, Processor 202 and Processor 204, are connected to a System Bus 206. Below the system bus, a Memory Controller/Cache 208 and an I/O Bridge 210 are shown. The Memory Controller/Cache 208 is connected to Local Memory 209. The I/O Bridge 210 is connected to an I/O Bus 212. The I/O Bus 212 is connected to several peripheral devices: Graphics Adapter 230, Hard Disk 232, and three PCI Bus Bridges (214, 222, and 224). Each PCI Bus Bridge is connected to an external PCI Bus (labeled 216, 226, and 228 respectively). The PCI Bus 216 is connected to a Modem 218 and a Network Adapter 220. The PCI Bus 226 and PCI Bus 228 are also shown with arrows indicating data flow.

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Attribute ::= SEQUENCE {
 type AttributeType,
 values SET OF AttributeValue
 }

AttributeType ::= OBJECT IDENTIFIER
 AttributeValue ::= ANY DEFINED BY type

Figure 3

ASN.1 Notation of the X.500
 Attribute data type
 AUS990800US1

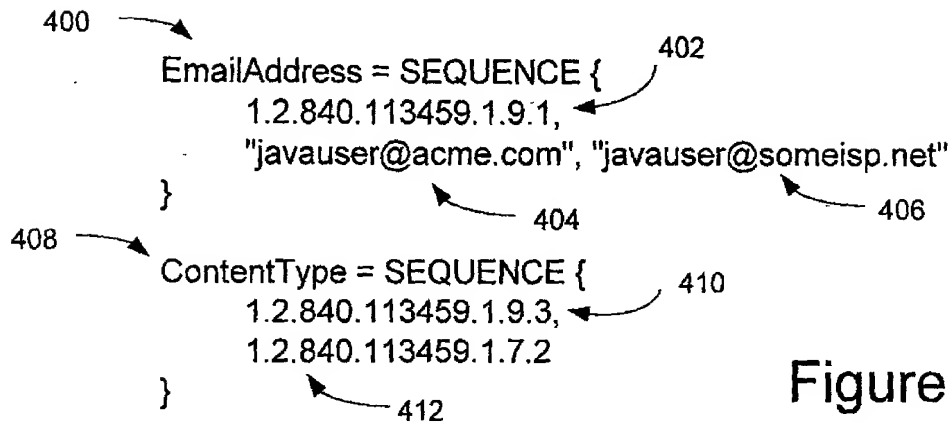


Figure 4

Attributes EmailAddress and
 ContentType using PKCS9
 AUS990800US1

EmailAddress 502	{	30	36	06	09	2A	86	48	86	F7	0D	01	09	01	31	29	16
		11	6A	61	76	61	75	73	65	72	40	61	63	6D	65	2E	63
		6F	6D	16	14	6A	61	76	61	75	73	65	72	40	73	6F	6D
		65	69	73	70	2E	6E	65	74								
ContentType 504	{	30	18	06	09	2A	86	48	86	F7	0D	01	09	03	31	0B	06
		09	2A	86	48	86	F6	33	01	07	02						

Figure 5

DER Encoding of EmailAddress
 and ContentType Attributes
 AUS990800US1

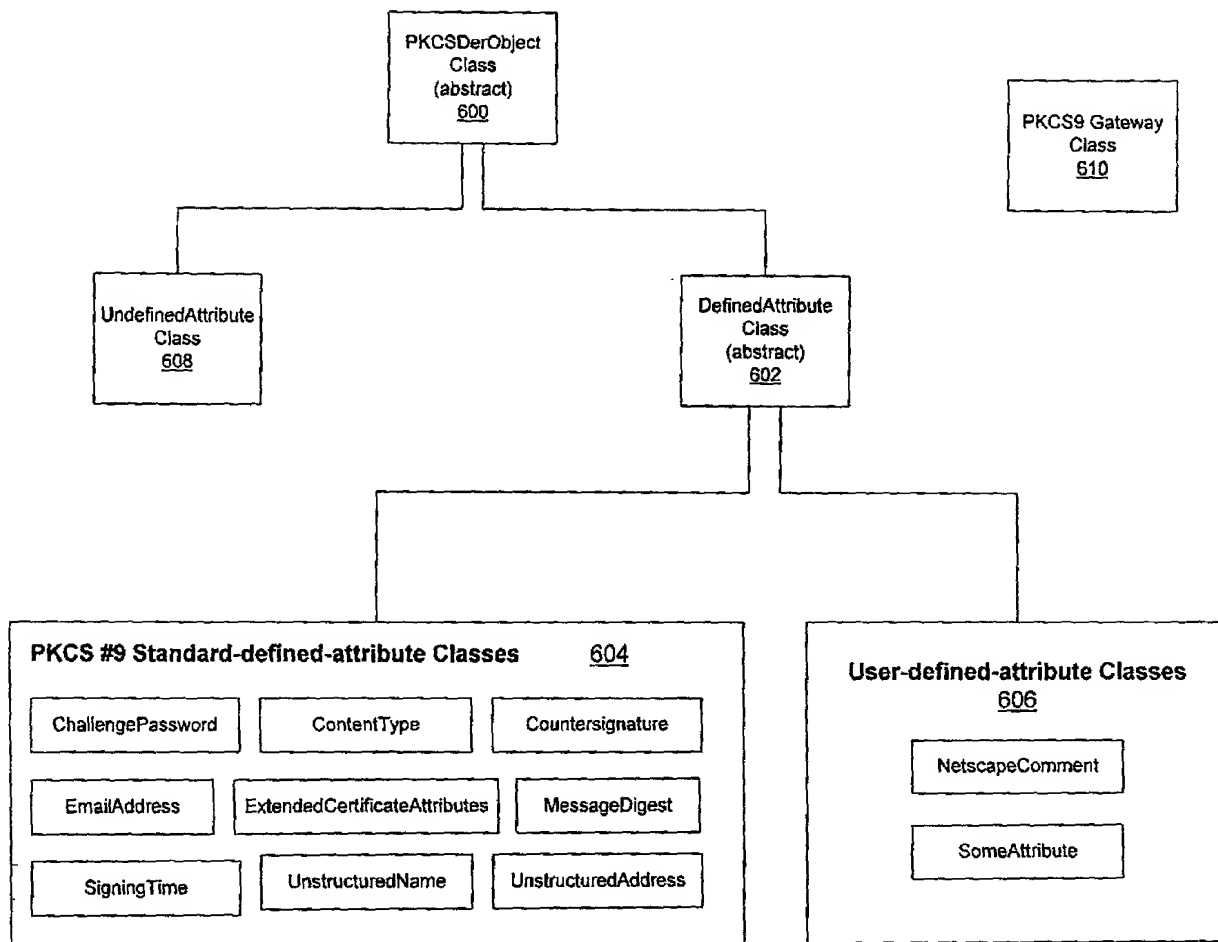


Figure 6
Attribute Classes and
Hierarchy
AUS990800US1

Figure 7A
Requesting an Attribute Object
via the PKCS9 class
AUS990800US1

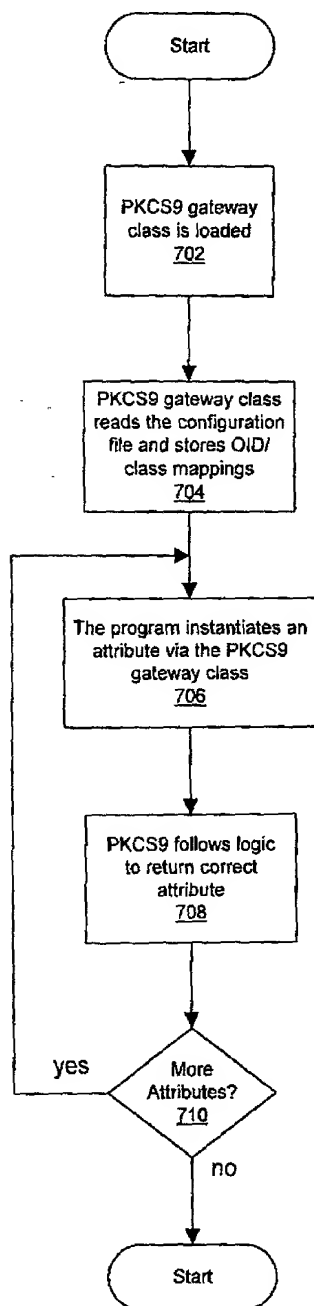


Figure 7B
Configuration File
AUS990800US1

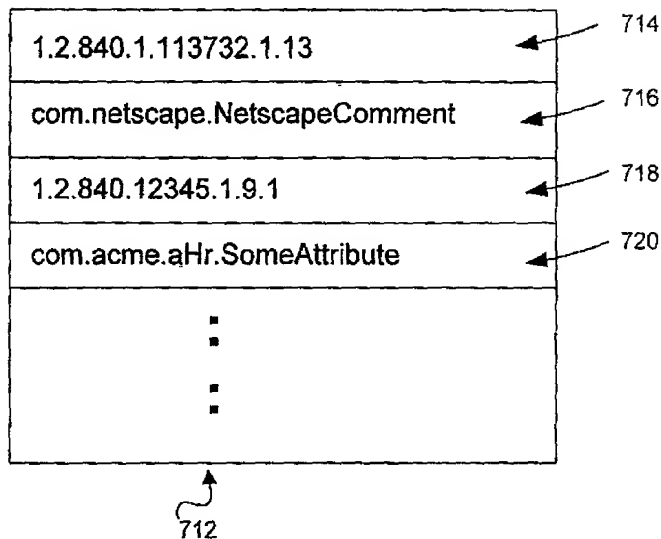


Figure 7C
Attribute Mapping
AUS990800US1

Object Identifier	Class
1.2.840.113549.1.9.1	EmailAddress
1.2.840.113549.1.9.2	UnstructuredName
1.2.840.113549.1.9.3	ContentType
1.2.840.113549.1.9.4	MessageDigest
1.2.840.113549.1.9.5	SigningTime
1.2.840.113549.1.9.6	Countersignature
1.2.840.113549.1.9.7	ChallengePassword
1.2.840.113549.1.9.8	UnstructuredAddress
1.2.840.113549.1.9.9	ExtendedCertificateAttributes
1.2.840.1.113732.1.13	com.netscape.NetscapeComment
1.2.840.12345.1.9.1	com.acme.aHr.SomeAttribute
⋮	⋮
⋮	⋮

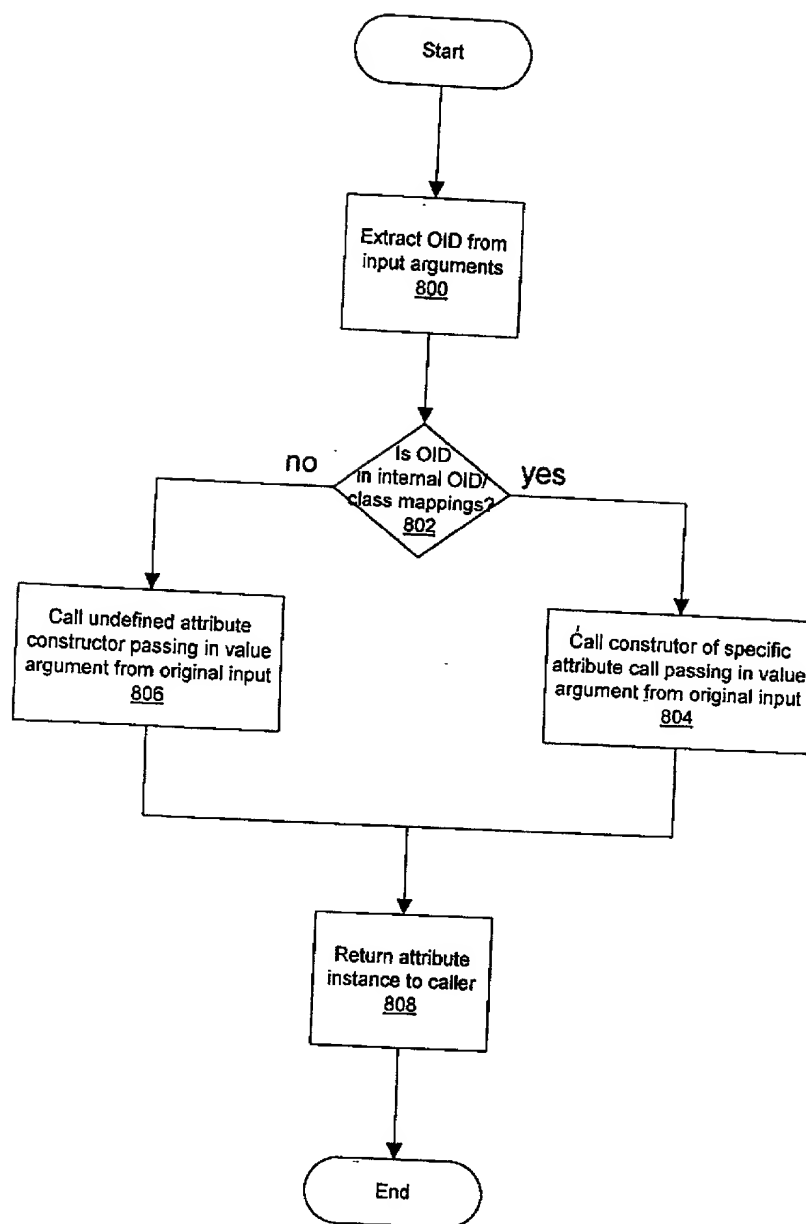


Figure 8
Logic of `getAttribute()` method
for PKCS9
AUS990800US1

**DECLARATION AND POWER OF ATTORNEY FOR
PATENT APPLICATION**

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name;

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

MANAGING AND EXTENDING ATTRIBUTE VALUES FOR PUBLIC KEY CRYPTOGRAPHY STANDARDS

the specification of which (check one)

X is attached hereto.

___ was filed on _____
as Application Serial No. _____
and was amended on _____
(if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the patentability of this application in accordance with Title 37, Code of Federal Regulations, §1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s):	Priority Claimed	
_____ (Number)	_____ (Country)	_____ (Day/Month/Year)
		___ Yes___ No

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose information material to the patentability of this application as defined in Title 37, Code of Federal Regulations, §1.56 which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

_____ (Application Serial #)	_____ (Filing Date)	_____ (Status)
---------------------------------	------------------------	-------------------

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorneys and/or agents to prosecute this application and transact all business in the Patent and Trademark Office connected therewith.

John W. Henderson, Jr., Reg. No. 26,907; Thomas E. Tyson, Reg. No. 28,543; James H. Barksdale, Jr., Reg. No. 24,091; Casimer K. Salys, Reg. No. 28,900; Robert M. Carwell, Reg. No. 28,499; Douglas H. Lefevre, Reg. No. 26,193; Jeffrey S. LaBaw, Reg. No. 31,633; David A. Mims, Jr., Reg. 32,708; Volel Emile, Reg. No. 39,969; Anthony V. England, Reg. No. 35,129; Leslie A. Van Leeuwen, Reg. No. 42,196; Christopher A. Hughes, Reg. No. 26,914; Edward A. Pennington, Reg. No. 32,588; John E. Hoel, Reg. No. 26,279; Joseph C. Redmond, Jr., Reg. No. 18,753; Marilyn S. Dawkins, Reg. No. 31,140; Mark E. McBurney, Reg. No. 33,114; Duke W. Yee, Reg. No. 34,285; Colin P. Cahoon, Reg. No. 38,836; Joseph R. Burwell, Reg. No. 44,468; Rudolph J. Buchel, Reg. No. 43,448; and Stephen R. Loe, Reg. No. 43,757.

Send correspondence to: Duke W. Yee, Carstens, Yee & Cahoon, LLP, P.O. Box 802334, Dallas, Texas 75380 and direct all telephone calls to Duke W. Yee, (972) 367-2001

FULL NAME OF SOLE OR FIRST INVENTOR: Anthony Joseph Nadalin

INVENTORS SIGNATURE: Anthony Joseph Nadalin DATE: January 5, 2000

RESIDENCE: 947 Vanguard
Austin, Texas 78734

CITIZENSHIP: United States

POST OFFICE ADDRESS: SAME AS ABOVE

FULL NAME OF SECOND INVENTOR: Bruce Arland Rich

INVENTORS SIGNATURE: Bruce Arland Rich DATE: January 5, 2000

RESIDENCE: 1808 Great Oaks Drive
Round Rock, Texas 78681

CITIZENSHIP: United States

POST OFFICE ADDRESS: SAME AS ABOVE

FULL NAME OF THIRD INVENTOR: Theodore Jack London Shrader

INVENTORS SIGNATURE: Theodore Jack London Shrader DATE: January 5, 2000

RESIDENCE: 408 Explorer
Austin, Texas 78734

DOCKET NUMBER: AUS990880US1

CITIZENSHIP: United States

POST OFFICE ADDRESS: SAME AS ABOVE

FULL NAME OF FOURTH INVENTOR: Julianne Yarsa

INVENTORS SIGNATURE: Julianne Yarsa DATE: January 5, 2000

RESIDENCE: 10904 Conchos Trail
Austin, Texas 78726

CITIZENSHIP: United States

POST OFFICE ADDRESS: SAME AS ABOVE